LAKE ST. JOSEPH TMDLS FOR DISSOLVED OXYGEN AND NUTRIENTS

May 28, 2002

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FOR DISSOLVED OXYGEN AND NUTRIENTS

SUBSEGMENT 081202

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources (NPS) discharging to the waterbody. This report presents TMDLs that have been developed for dissolved oxygen (DO) and nutrients for Lake St. Joseph (subsegment 081202) in the Ouachita River basin in northern Louisiana.

Lake St. Joseph is an oxbow lake located approximately 24 miles south of Tallulah, LA and approximately 30 miles east of Winnsboro, LA. The drainage area for the lake is approximately 23 mi^2. The lake is located in a region where the land use is largely agricultural and the topography is generally flat.

Lake St. Joseph was listed on the Modified Court Ordered 303(d) List for Louisiana as not fully supporting the designated uses of propagation of fish and wildlife and was ranked as priority #2 for TMDL development. The suspected causes for impairment cited in the 303(d) List included organic enrichment/low DO and nutrients. The water quality standard for DO in this subsegment is 5 mg/L year round.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in Lake St. Joseph. The model was set up and calibrated using LDEQ assessment data collected during January through December 1999, data from a synoptic survey conducted by FTN Associates, Ltd. (FTN) during August 2001, and other various information obtained from LDEQ and US Geological Survey (USGS). There were no intensive survey data available for this subsegment. The projection simulation was run at critical flows and temperatures to address seasonality as required by the Clean Water Act. Reductions of existing NPS loads were required for the projection simulation to show the DO standard of 5 mg/L being maintained. In general, the modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures Manual.

The TMDL for oxygen demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand (SOD)) was calculated using the results of the projection simulation. Both implicit and explicit margins of safety (MOS) were included in the TMDL calculations. The nutrient TMDL was developed based on Louisiana's water quality standard for nutrients, which states that "the naturally occurring range of nitrogen to phosphorus ratios shall be maintained." The nutrient TMDL was calculated using allowable nitrogen loadings from the projection simulation and applying a naturally occurring nitrogen to phosphorus ratio to determine the allowable phosphorous loadings.

The projection modeling showed that NPS loads will need to be reduced by approximately 6% in order to meet the DO standard of 5 mg/L in Lake St. Joseph.

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for dissolved oxygen (DO) and nutrients for Lake St. Joseph (subsegment 081202). This subsegment was listed on the February 29, 2000 Modified Court Ordered 303(d) List for Louisiana (EPA 2000) as not fully supporting the designated use of propagation of fish and wildlife. The suspected sources and suspected causes for impairment in the 303(d) List are included in Table 1.1. Lake St. Joseph was ranked as priority #2 for TMDL development. The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and EPA's regulations at 40 CFR 130.7. The 303(d) Listings for other pollutants in this subsegment are being addressed by EPA and the Louisiana Department of Environmental Quality (LDEQ) in other documents.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern, and the LA is the load that is allocated to nonpoint sources (NPS). The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions, data inadequacies, and future growth.

Table 1.1. Summary of 303(d) listing for subsegment 081202 (EPA 2000).

Subsegment Number	Waterbody Description	Suspected Sources	Suspected Causes	Priority Ranking (1 = highest)
081202	Lake St. Joseph	Irrigated crop production Surface runoff Petroleum activities	Pesticides Nutrients Organic enrichment/low DO Suspended solids	2

2.0 STUDY AREA DESCRIPTION

2.1 General Information

Lake St. Joseph is a 1580-acre lake located approximately 24 miles south of Tallulah, LA and approximately 30 miles east of Winnsboro, LA (see Figures A.1 and A.2 located in Appendix A). The lake is an oxbow lake that was originally formed by the Mississippi River. The levee along the Mississippi River now forms the eastern border of the lake's watershed. Lake St. Joseph's drainage area is approximately 23 mi^2 (USGS 1971), which is primarily in the southern half of subsegment 081202. Some areas in the northern part of this subsegment drain westward toward the Tensas River without entering Lake St. Joseph. The outlet of the lake is Clark Bayou, which drains into the Tensas River. The topography of the area is generally flat.

Lake St. Joseph is located in a region that is largely agricultural. The only town within this subsegment is Newellton. Land use data for this subsegment are shown in Table 2.1. Some of the wetland areas in the northern part of the subsegment were apparently classified as open water in the GAP land use data.

Table 2.1. Land uses in subsegment 081202 based on GAP data (USGS 1998).

Land Use Type	% of Total Area
Fresh Marsh	6.8%
Saline Marsh	0.0%
Wetland Forest	5.2%
Upland Forest	3.0%
Wetland scrub/shrub	0.0%
Upland scrub/shrub	0.0%
Agricultural	13.5%
Urban	9.8%
Barren	0.0%
Water	61.7%
TOTAL	100.0%

2.2 Water Quality Standards

The numeric water quality standards and designated uses for Lake St. Joseph are shown in Table 2.2. The primary numeric standard for the TMDLs presented in this report is the DO standard of 5 mg/L year round.

For nutrients, there are no specific numeric criteria, but there is a narrative standard that states "The naturally occurring range of nitrogen-phosphorus ratios shall be maintained.... Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters." (LDEQ 2000).

In addition, LDEQ issued a declaratory ruling on April 29, 1996, concerning this language and stated, "That DO directly correlates with overall nutrient impact is a well-established biological and ecological principle. Thus, when the LDEQ maintains and protects DO, the LDEQ is in effect also limiting and controlling nutrient concentrations and impacts." DO serves as the indicator for the water quality criteria and for assessment of use support. For the TMDLs in this report, the nutrient loading required to maintain the DO standard is the nutrient TMDL.

2.3 Identification of Sources

2.3.1 Point Sources

A listing of all NPDES permits in the Ouachita and Calcasieu River basins was searched to identify any permits within the Lake St. Joseph subsegment (081202). This listing was prepared by EPA Region 6 using databases and permit files from LDEQ. Based on this listing, no NPDES permits were identified within subsegment 081202. Therefore, no point sources were included in the model or TMDL calculations for this subsegment.

Table 2.2. Water quality standards and designated uses (LDEQ 2000).

Subsegment Number	081202
Waterbody Description	Lake St. Joseph
Designated Uses:	ABC
Criteria:	
Chloride	25 mg/L
Sulfate	25 mg/L
DO	5 mg/L (year round)
pH	6.0 – 8.5
Temperature	32° C
TDS	150 mg/L

USES: A – primary contact recreation; B – secondary contact recreation; C – propagation of fish and wildlife; D – drinking water supply; E – oyster propagation; F – agriculture; G – outstanding natural resource water; L – limited aquatic life and wildlife use.

2.3.2 Nonpoint Sources

Several nonpoint sources were cited as suspected causes of impairment for Lake St. Joseph in the 303(d) List (Table 1.1). These nonpoint sources include irrigated crop production, surface runoff, and petroleum activities.

2.4 Previous Data and Studies

Listed below are previous water quality data and studies in or near the Lake St. Joseph subsegment. Locations of both LDEQ stations are shown on Figure A.2 in Appendix A.

1) Monthly data collected by LDEQ for "Lake St. Joseph in Newellton, LA" (station 0800) for January through December 1999. This station is located on the Highway 605 bridge over Clark Bayou (the outlet of the lake).

2) Monthly data collected by LDEQ for "Lake Bruin at North End near Newellton, LA" (station 0140) from 1985 through 1999. This station is located approximately 3-4 miles south of station 0800 on another oxbow lake.

3) Data collected by USGS for Lake St. Joseph (station 07369647). This station is at the same location as LDEQ station 0800. These data were collected 3-4 times per year for 1977 through 1986 plus several other dates during 1962 through 1976.

3.0 CALIBRATION OF WATER QUALITY MODEL

3.1 Model Setup

In order to evaluate the linkage between pollutant sources and water quality, a computer simulation model was used. The model used for these TMDLs was LA-QUAL (version 4.13), which was selected because it includes the relevant physical, chemical, and biological processes and it has been used successfully in the past for other TMDLs in Louisiana. The LA-QUAL model was set up to simulate organic nitrogen, ammonia nitrogen, ultimate carbonaceous biochemical oxygen demand (CBODu), and DO. This model was set up as one reach with one element because there were no physical or chemical data to provide evidence of spatial variations in water quality.

3.2 Calibration Period and Calibration Targets

An intensive field survey was not performed for the study area due to schedule and budget limitations. A synoptic survey of the study area was performed by FTN in August 2001, but only limited data were collected during that survey. The model was calibrated to historical conditions when hydrologic and water quality data were available. The only historical water quality data for Lake St. Joseph were the LDEQ data collected during 1999 and the USGS data collected during 1962-86 (both sets of data are shown in Appendix B). The LDEQ data were chosen for calibration rather than the USGS data because: 1) the LDEQ data were collected at more frequent intervals than the USGS data and 2) the LDEQ data should be more representative of current conditions because they were collected more recently.

The LDEQ water quality data for station 0800 were retrieved from the LDEQ website and examined to identify a critical period for DO. The two conditions that usually characterize critical periods for DO are high temperatures and low flows. High temperatures decrease DO saturation values and increase rates for oxygen demanding processes (biochemical oxygen demand (BOD) decay, nitrification, and sediment oxygen demand (SOD)). The purpose of selecting a critical period for calibration is so that the model will be calibrated as accurately as possible for making projection simulations for critical conditions.

After examining the LDEQ data in Appendix B, the calibration period was selected as July 6 through September 7, 1999. This period represented the most critical period for DO. The calibration target (i.e., the concentration to which the model was calibrated) for each parameter for each LDEQ station was set to the average of the concentrations measured during the calibration period. The LDEQ routine monitoring data did not include carbonaceous biochemical oxygen demand (CBOD), but there were measurements of total organic carbon (TOC). Therefore, the calibration target for CBODu was estimated from the TOC data based on statistics from LDEQ's long term BOD analyses. The LDEQ's long term BOD analyses consisted of 140 samples from intensive surveys in the Ouachita River basin during 2001. These samples were analyzed for numerous parameters including CBODu and TOC. The ratio of CBODu to TOC was calculated for each sample and the median of those 140 ratios was determined to be 1.10. Using this result, the CBODu calibration target was estimated as 1.10 times the average TOC during the calibration period. Data from the LDEQ long term BOD analyses are shown in Appendix C.

3.3 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (the "LTP"; LDEQ 2001). These correction factors were:

- Correction for BOD decay: 1.047 (value in LTP is same as model default)
- Correction for SOD: 1.065 (value in LTP is same as model default)
- Correction for ammonia N decay: 1.070 (specified in Data Group 4)
- Correction for organic N decay: 1.020 (not specified in LTP; model default used)
- Correction for reaeration: automatically calculated by the model

3.4 Hydraulics (Data Type 9)

The hydraulics were specified in the input for the LA-QUAL model using the power functions (width = a * Q^b and depth = c * Q^d + e). Under low flow conditions the depth and width of Lake St. Joseph can be assumed to be independent of flow rate. Therefore, the system was modeled with constant depth and width. This was specified in the model by setting the coefficients and exponents as follows:

- width coefficient (a) = 0.0
- width exponent (b) = 0.0
- width constant (c) = estimated width = 311 m
- depth coefficient (d) = 0.0
- depth exponent (e) = 0.0
- depth constant (f) = estimated depth = 1.9 m

The width was estimated as the surface area of the lake divided by the approximate length of the lake. Both the surface area and length of the lake were measured from digital ortho quarter quads (DOQQs). The depth was estimated based on the average depth measured at LDEQ station 0800 during the FTN synoptic survey. Data from the FTN synoptic survey are shown in Appendix D. Tables summarizing the model inputs for calibration are shown in Appendix E.

3.5 Initial Conditions (Data Type 11)

The primary parameter that is specified in the initial conditions for LA-QUAL is the temperature (because temperature was not being simulated). The temperature for Lake St. Joseph was set to the average of the measured values at LDEQ station 0800 during the calibration period. The model input values for the calibration are summarized in Appendix E.

One other parameter that was specified in the initial conditions was chlorophyll. Chlorophyll was not simulated in the model (i.e., it was not “turned on” in Data Group 2), but a chlorophyll value was entered as an initial condition and used as a calibration parameter to calibrate the model for DO. The calibration methodology is discussed in Section 3.11.

For other constituents not being simulated, the initial concentrations were set to zero; otherwise, the model would have assumed a fixed concentration of those constituents and the model would have included the effects of the unmodeled constituents on the modeled constituents.

3.6 Water Quality Kinetics (Data Types 12 and 13)

Kinetic rates used in LA-QUAL include reaeration rates, CBOD decay rates, nitrification rates, and mineralization rates (organic nitrogen decay). The values used in the model input are shown in Appendix E.

Reaeration was specified in the model using a surface transfer coefficient (option 20). Because the lake is wide and not sheltered from the wind, the effect of wind on reaeration was included. A wind-aided surface transfer coefficient was calculated using measured wind speeds from the Vicksburg-Tallulah station. These daily wind speeds were averaged over the calibration period, corrected to a height of 0.1 m, and then used to calculate a wind-aided surface transfer coefficient of 0.84 m/day. These data and calculations are shown in Appendix F.

The rates for CBOD decay and nitrification (ammonia nitrogen "decay") were based on median values of laboratory decay rates from LDEQ's long term BOD analyses. The LDEQ long term BOD analyses consisted of 140 samples from intensive surveys in the Ouachita River basin during 2001. The median decay rates for CBOD and nitrogenous biochemical oxygen demand (NBOD) were approximately 0.06/day and 0.07/day, respectively. These data are shown in Appendix C. Because instream decay rates are typically slightly higher than laboratory decay rates, both the CBOD decay rates and the nitrification rates were set to 0.10/day.

The mineralization rate (organic nitrogen decay) in the model was set to 0.02/day. This value was similar to the values shown in Table 5.3 of the "Rates, Constants, and Kinetics" publication (EPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen. The literature values for mineralization rates are shown in Appendix G.

One other input value was specified for characterizing the nitrification process. In the program constants section of the model input file (data type 3), the nitrification inhibition option was set to 1 instead of the default of option number 2. With the default option, the nitrification rate drops rapidly when the DO drops below 2 mg/L, which results in an unrealistic build up of ammonia nitrogen at low DO. Option number 1 provides nitrification inhibition that is similar to what is simulated in other widely used water quality models such as QUAL2E and WASP (see Figure 3.5 in FTN 2000).

3.7 Nonpoint Source Loads (Data Type 19)

The NPS loads that are specified in the model can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, benthic ammonia source rate, CBODu loads, and organic nitrogen loads. The SOD (specified in data type 12), the benthic ammonia source rates (specified in data type 13), and the mass loads of organic nitrogen and

CBODu (specified in data type 19) were all treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values. The procedures used for calibrating the model are discussed in Section 3.11. The values used as model input are shown in Appendix E.

3.8 Headwater Flow Rate (Data Type 20)

The headwater inflow to Lake St. Joseph was estimated using USGS daily flow data for the Tensas River at Tendal (gage number 07369500). The flow data for this gage were averaged for the calibration period and divided by the drainage area at the gage to obtain a flow per unit area of 0.197 cfs/mi^2 for the calibration period. This flow per unit area was then multiplied by the drainage area of Lake St. Joseph (23.15 mi^2) to obtain a headwater inflow rate of 4.56 cfs (0.129 m^3/sec). The data and calculations used to develop the headwater inflow rate are shown in Appendix H.

3.9 Headwater Quality (Data Type 21)

No water quality data were available for inflows to Lake St. Joseph; all existing data have been collected at the outlet of the lake. Therefore, the headwater concentrations of DO, CBODu, organic nitrogen, and ammonia nitrogen were based on data from 4 LDEQ stations in nearby agricultural areas that were considered similar to the Lake St. Joseph watershed. Data for each station were averaged for July through September 1999 and then the data for all 4 stations were averaged together to obtain the values used in the model input. CBODu was estimated from TOC using data from LDEQ's long term BOD analyses in the same manner as described in Section 3.2. The 1999 data for these 4 LDEQ stations are shown in Appendix I and the values used as model input are shown in Appendix E.

3.10 Point Source Inputs (Data Types 24-25)

As discussed in Section 2.3.1, no NPDES permits were identified within subsegment 081202. Therefore, no point source discharges were included in the model.

3.11 Calibration Methodology

The model was calibrated by adjusting 5 input parameters: organic nitrogen loads, benthic ammonia source rates, CBODu mass loads, SOD, and the chlorophyll concentration. First, the organic nitrogen loads were adjusted until the predicted organic nitrogen concentrations were similar to the observed concentrations. Organic nitrogen was calibrated first because none of the other state variables (DO, CBODu, ammonia nitrogen) will affect the organic nitrogen concentrations. Next, the benthic ammonia source rates were adjusted until the predicted ammonia nitrogen concentrations were similar to the observed concentrations. Then the CBODu loads were adjusted until the predicted CBODu concentrations were similar to the observed concentrations.

After the organic nitrogen, ammonia nitrogen, and CBODu were calibrated, an attempt was made to calibrate the DO by adjusting the SOD. However, the predicted DO was lower than the calibration target even after reducing the SOD to zero. Therefore, a chlorophyll concentration was specified in the initial conditions to account for the effects of algae on DO. This was considered reasonable because most lakes in Louisiana have significant algal productivity. On several occasions during 1999, the LDEQ data show DO values above saturation, which can only occur from algal photosynthesis.

Because no chlorophyll data were available for the lake, the chlorophyll concentration was used as a calibration parameter. The SOD was set to 0.5 $g/m^2/day$, which was considered to be a reasonable value for a shallow lake in Louisiana. Then the chlorophyll concentration was adjusted until the predicted DO concentration was similar to the calibration target for DO. Because adding the chlorophyll increased the “effective CBODu” concentration in the model, the CBODu mass load was then reduced until the predicted “effective CBODu” concentration was similar to the calibration target for CBODu. Then the DO calibration was refined again by adjusting the chlorophyll slightly. This iteration of fine tuning the CBODu mass load the chlorophyll concentration was repeated several times until a close match between predicted and observed values was achieved for both the CBODu and DO.

The reason that the chlorophyll affects the predicted “effective CBODu” concentration in the model is that the model assumes that a measured CBODu concentration will include oxygen demand from algal respiration and death in addition to oxygen demand from decay of dissolved substances in the water. The model provides a coefficient in Data Type 3 to account for this effect. This coefficient was set to 0.175 mg/L of BOD per µg/L of chlorophyll, which was the midpoint of the range recommended in the LA-QUAL User's Manual.

3.12 Model Results for Calibration

Plots of predicted and observed water quality for the calibration are presented in Appendix J and a printout of the LA-QUAL output file is included as Appendix K. The calibration was considered to be acceptable based on the amount of data that were available.

4.0 WATER QUALITY MODEL PROJECTION

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, the calibrated model was used to project water quality for critical conditions. The identification of critical conditions and the model input data used for critical conditions are discussed below.

4.1 Identification of Critical Conditions

Section 303(d) of the Federal Clean Water Act and EPA's regulations at 40 CFR 130.7 both require the consideration of seasonal variation of conditions affecting the constituent of concern and the inclusion of a MOS in the development of a TMDL. For the TMDLs in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. A combination of implicit and explicit MOS was used in developing the projection model.

Critical conditions for DO have been determined for Louisiana waterbodies in previous TMDL studies. The analyses concluded that the critical conditions for stream DO concentrations occur during periods with negligible nonpoint runoff, low stream flow, and high stream temperature.

When the rainfall runoff (and nonpoint loading) and stream flow are high, turbulence is higher due to the higher flow and the stream temperature is lowered by the cooler precipitation and runoff. In addition, runoff coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. DO saturation values are, of course, much higher when water temperatures are cooler, but BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and DO but not necessarily periods of high BOD decay.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the stream, which is, in turn, expressed as SOD and/or resuspended BOD in the model. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow.

According to the LTP, critical summer conditions in DO TMDL projection modeling are simulated by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the summer season. Model loading is from perennial tributaries, SOD, and resuspension of sediments.

In reality, the highest temperatures occur in July and August and the lowest stream flows occur in October and November. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. Over and above this implicit MOS, an explicit MOS of 10% for NPS was incorporated into the TMDL in this report to account for model uncertainty.

4.2 Temperature Inputs

The LTP (LDEQ 2001) specifies that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. Because the LDEQ station for Lake St. Joseph has only 12 months of data, LDEQ data from another subsegment were used for this analysis. Long term temperature data from Lake Bruin at North End (LDEQ station 0140) were used to calculate a 90^{th} percentile summer temperature of 31.9EC. However, the water temperatures for the Lake St. Joseph station during May through October 1999 were slightly cooler than the temperatures in Lake Bruin during that time. Therefore, the critical temperature for Lake St. Joseph was estimated as the 90^{th} percentile summer temperature for Lake Bruin (31.9EC) minus the average temperature difference (1.3EC) during May through October 1999 between Lake Bruin and Lake St. Joseph. The critical temperature calculated for Lake St. Joseph was 30.6EC. This value was specified in data type 11 in the model input and is shown in Appendix L along with other model inputs for the projection. The data for these calculations are shown in Appendix M.

Because Lake St. Joseph has a year round standard for DO, a winter projection simulation was not performed. As discussed above, the most critical time of year for meeting a constant DO standard is the period of high temperatures and low flows (i.e., summer).

4.3 Headwater Inputs

There are no USGS flow gages and no published 7Q10 values for the inflow to Lake St. Joseph. The LTP specifies that the critical flow rate for summer should be set to the 7Q10 flow or 0.1 cfs, whichever is smaller. A 7Q10 flow was estimated for the Lake St. Joseph inflow based on the published 7Q10 for the Tensas River at Tendal (USGS gage number 07369500). The published 7Q10 for this gage (4.2 cfs; USGS 1980) was divided by the drainage area for the gage (309 mi^2) and then multiplied by the drainage area of Lake St. Joseph (23.15 mi^2) to obtain an estimated 7Q10 of 0.31 cfs for Lake St. Joseph. Because the estimated 7Q10 was greater than 0.1 cfs, the headwater inflow in the model was set to 0.31 cfs (0.009 m^3/sec). The published 7Q10 information for the Tensas River at Tendal is shown in Appendix N.

For headwater quality, the DO was set to 90% saturation at the critical temperature (as specified in the LTP). All other water quality concentrations were the same as in the calibration model. The values used as model input for the projection are shown in Appendix L.

4.4 Point Source Inputs

As discussed in Section 2.3.1, no NPDES permits were identified within subsegment 081202. Therefore, no point source discharges were included in the model.

4.5 Nonpoint Source Loads

Because the initial projection simulation showed low DO values, the NPS loadings were reduced until all of the predicted DO values were equal to or greater than the water quality standard of 5.0 mg/L. The same percent reduction was applied to all components of the NPS loads (SOD, benthic ammonia source rates, and mass loads of CBODu and ammonia nitrogen). The values used as model input for the projection simulation are shown in Appendix L.

4.6 Reaeration

For the projection simulation, the reaeration was specified based on an evaluation of long term average wind speeds as compared to wind speeds during the calibration period. Because long term data for wind speeds were not available for the Vicksburg-Tallulah station, data from the Baton Rouge and Shreveport stations were used for the comparison. As shown in Appendix F, the long term average wind speeds for July and August were greater than the values for July and August 1999. Because the calibration period represented conditions with lower reaeration than for long term average conditions, it was decided to keep the surface transfer coefficient for the projection at the same value used in the calibration (0.84 m/day). This was more conservative than calculating a new surface transfer coefficient based on the long term average wind speeds.

4.7 Other Inputs

The only model inputs that were changed from the calibration to the projection simulation were the inputs discussed above in Sections 4.2 – 4.6. All of the other model inputs (e.g., hydraulic coefficients, decay rates, etc.) were unchanged from the calibration simulation. Based on guidance in Section 3.4.1.6 of the LTP, the chlorophyll concentration was kept at the same value used in the calibration.

4.8 Model Results for Projection

Plots of predicted water quality for the projection are presented in Appendix O and a printout of the LA-QUAL output file is included as Appendix P.

A NPS load reduction of 6% was required to bring the predicted DO values to at least 5.0 mg/L. This percentage reduction for NPS loads represents a percentage of the entire NPS loading, not a percentage of the manmade NPS loading. The NPS loads in this report were not divided between natural and manmade because it would be difficult to estimate natural NPS loads for Lake St. Joseph.

5.0 TMDL CALCULATIONS

5.1 DO TMDL

A TMDL for DO has been calculated for Lake St. Joseph based on the results of the projection simulation. The DO TMDL is presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. A summary of the loads is presented in Table 5.1.

The TMDL calculations were performed using a FORTRAN program that was written by FTN personnel. This program reads two files; one is the LA-QUAL output file from the projection simulation and the other is a small file with miscellaneous information needed for the TMDL calculations (shown in Appendix Q). The output from the program is shown in Appendix R and the source code for the program is shown in Appendix S.

Table 5.1. DO TMDL for subsegment 081202 (Lake St. Joseph).

	Oxygen demand (kg/day) from:				Total oxygen demand (kg/day)
	CBODu	Organic N	Ammonia N	SOD	
WLA for minor point sources	0	0	0	0	0
MOS for point sources	0	0	0	0	0
LA for NPS	22580.77	3599.78	0.18	328.29	26509.02
MOS for NPS	2508.97	399.98	0.02	36.48	2945.45
Total maximum daily load	25089.74	3999.76	0.20	364.77	29454.47

The oxygen demand from organic nitrogen and ammonia nitrogen was calculated as 4.33 times the nitrogen loads (assuming that all organic nitrogen is eventually converted to ammonia). The value of 4.33 is the same ratio of oxygen demand to nitrogen that is used by the LA-QUAL model. For the SOD loads, a temperature correction factor was included in the calculations (in order to be consistent with LDEQ procedures).

5.2 Nutrient TMDL

Because Lake St. Joseph was on the 303(d) List for nutrients as well as DO (see Table 1.1), a nutrient TMDL was also developed. As discussed in Section 2.2, Louisiana has no numeric standards for nutrients, but has a narrative standard that states that “the naturally occurring range of nitrogen-phosphorus ratios shall be maintained” (LDEQ 2000). For this

TMDL, nutrients were defined as total nitrogen (organic nitrogen plus ammonia nitrogen plus nitrate/nitrite nitrogen) and total phosphorus. The value used for the naturally occurring nitrogen to phosphorus ratio was 8.0. This ratio was based on LDEQ reference stream data for the Upper Mississippi Alluvial Plain ecoregion (Smythe 1999). These data are shown in Appendix T.

The first step in calculating the nutrient TMDL was to determine the loads of total nitrogen (TN) that were simulated in the projection model. The loads in the projection model represent the maximum allowable loads that will maintain DO standards. Then the allowable loads of total phosphorus (TP) were calculated by dividing the TN loads by the naturally occurring ratio of TN to TP. The resulting loads of TN and TP for Lake St. Joseph are presented in Table 5.2.

Table 5.2. Nutrient TMDL for subsegment 081202 (Lake St. Joseph).

	Organic N (kg/day)	**Ammonia N (kg/day)**	**NO_2+NO_3 N (kg/day)**	**Total N (kg/day)**	**Total P (kg/day)**
WLA for point sources	0	0	0	0	0
MOS for point sources	0	0	0	0	0
LA for NPS	831.36	0.04	0.18	831.58	103.95
MOS for NPS	92.37	0.01	0.02	92.40	11.55
Total Maximum Daily Load	923.73	0.05	0.20	923.98	115.50

5.3 Ammonia Toxicity Calculations

Although subsegment 081202 is not on the 303(d) List for ammonia, the ammonia concentrations predicted by the projection model were checked to make sure that they did not exceed EPA criteria for ammonia toxicity (EPA 1999). The EPA criteria are dependent on temperature and pH. The water temperature used to calculate the ammonia toxicity criterion for Lake St. Joseph was the same as the critical temperature used in the projection simulation (30.6°C). For pH, an average of the values measured at LDEQ station 0800 during the calibration period was used. The resulting criterion was 1.5 mg/L of ammonia nitrogen. The inlake ammonia nitrogen concentration predicted by the LA-QUAL model (0.4 mg/L) was well below the criterion. This indicates that the ammonia nitrogen loadings that will maintain the DO standard are low enough that the EPA ammonia toxicity criteria will not be exceeded under critical conditions. The ammonia toxicity calculations are shown in Appendix U.

5.4 Summary of NPS Reductions

In summary, the projection modeling used to develop the TMDLs above showed that NPS loads need to be reduced by 6% to maintain the DO standard in Lake St. Joseph.

5.5 Seasonal Variation

As discussed in Section 4.1, critical conditions for DO in Louisiana waterbodies have been determined to be when there is negligible nonpoint runoff and low stream flow combined with high water temperatures. In addition, the model accounts for loadings that occur at higher flows by modeling sediment oxygen demand. Oxygen demanding pollutants that enter the waterbodies during higher flows settle to the bottom and then exert the greatest oxygen demand during the high temperature seasons.

5.6 Margin of Safety

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between load allocations and water quality. As discussed in Section 4.1, the highest temperatures occur in July – August and the lowest stream flows occur in October – November. The combination of these conditions, in addition to other conservative assumptions regarding rates and loadings, yields an implicit MOS which is not quantified. In addition to the implicit MOS, the TMDLs in this report include an explicit margin of safety of 10% for NPS loads.

6.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. It is therefore of value to consider the sensitivity of the model output to changes in model coefficients, and in the hypothesized relationships among the parameters of the model. The sensitivity analyses were performed by allowing the LA-QUAL model to vary one input parameter at a time while holding all other parameters to their original value. The calibration simulation was used as the baseline for the sensitivity analysis. The percent change of the model's minimum DO projections to each parameter is presented in Table 6.1. Each parameter was varied by "30%, except for temperature, which was varied "2ºC.

Values reported in Table 6.1 are sorted by percentage variation of minimum DO from smallest percentage variation to largest. Velocity, reaeration, and depth were the parameters to which DO was most sensitive.

Table 6.1. Summary of results of sensitivity analyses.

Input Parameter	**Parameter Change**	**Predicted Minimum DO (mg/L)**	**Percent Change in Predicted DO (%)**
Baseline	-	4.69	N/A
BOD decay rate	+30%	4.68	< 1
BOD decay rate	-30%	4.69	< 1
Dispersion	+30%	4.69	< 1
Dispersion	-30%	4.69	< 1
Headwater flow	-30%	4.68	< 1
Headwater flow	+30%	4.69	< 1
NH3 decay rate	+30%	4.68	< 1
NH3 decay rate	-30%	4.69	< 1
Organic N decay rate	+30%	4.68	< 1
Organic N decay rate	-30%	4.69	< 1
Initial temperature	+2ºC	4.67	< 1
Initial temperature	-2ºC	4.71	< 1
SOD	-30%	4.98	6
SOD	+30%	4.39	6
Depth	+30%	5.20	11
Reaeration	+30%	5.20	11
Velocity	-30%	5.20	11
Depth	-30%	3.83	18
Reaeration	-30%	3.52	25
Velocity	+30%	3.31	29

Note: “Wasteload” parameters were not included in the sensitivity analysis because there were no tributaries or point source discharges in the model.

7.0 OTHER RELEVANT INFORMATION

This TMDL has been developed to be consistent with the antidegradation policy in the LDEQ water quality standards (LAC 33:IX.1109.A).

Although not required by this TMDL, LDEQ utilizes funds under Section 106 of the Federal Clean Water Act and under the authority of the Louisiana Environmental Quality Act to operate an established program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (Water Quality Inventory) and the 303(d) List of impaired waters. This information is also utilized in establishing priorities for the LDEQ NPS program.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-year cycle. This will allow the LDEQ to determine whether there has been any improvement in water quality following establishment of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) List. The sampling schedule for the first five-year cycle is shown below. The Ouachita River Basin will be sampled again in 2004.

1998 – Mermentau and Vermilion-Teche River Basins
1999 – Calcasieu and Ouachita River Basins
2000 – Barataria and Terrebonne Basins
2001 – Lake Pontchartrain Basin and Pearl River Basin
2002 – Red and Sabine River Basins

(Atchafalaya and Mississippi Rivers will be sampled continuously.)

In addition to ambient water quality sampling in the priority basins, the LDEQ has increased compliance monitoring in those basins, following the same schedule. Approximately 1,000 to 1,100 permitted facilities in the priority basins were targeted for inspections. The goal set by LDEQ was to inspect all of those facilities on the list and to sample 1/3 of the minors and 1/3 of the majors.

8.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, 40 CFR §130.7(d)(2) requires EPA to publicly notice and seek comment concerning the TMDL. Pursuant to an October 1, 1999 Court Order, this TMDL was prepared under contract to EPA. After development of the draft of this TMDL, EPA commenced preparation of a notice seeking comments, information, and data from the general and affected public. Comments and additional information were submitted during the public comment period and this TMDL was revised accordingly. Responses to these comments and additional information are included in Appendix V. EPA has transmitted this revised TMDL to LDEQ for incorporation into LDEQ's current water quality management plan.

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APPENDIX A THROUGH U AVAILABLE THROUGH EPA UPON REQUEST

APPENDIX V

Response to Comments

COMMENTS AND RESPONSES
LAKE ST. JOSEPH TMDLs FOR DO AND NUTRIENTS
May 28, 2002

EPA appreciates all comments concerning these TMDLs. Comments that were received are shown below with EPA responses or notes inserted in a different font.

GENERAL COMMENTS FROM LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY (LDEQ):

Note: LDEQ submitted one document containing comments on 98 TMDLs for various pollutants and subsegments throughout the Ouachita and Calcasieu basins. Only the portions of that comment document that apply to the DO and nutrient TMDLs in the Ouachita basin (10 subsegments) are shown below. Some of the general comments may not apply to this report.

The Louisiana Department of Environmental Quality hereby submits comments on the 98 TMDLs and the calculations for these TMDLs prepared by EPA Region 6 for waters listed in the Calcasieu and Ouachita river basins, under section 303(d) of the Clean Water Act. Listed below are general comments.

1. Many of these TMDLs are based on models using historical water quality data gathered at a single or small number of locations rather than survey data gathered at sites spaced throughout the waterbody. The hydraulic information used was generally an average value or estimated value, not taken at the same time as the water quality data. The calibrations are inadequate due to the lack of appropriate hydrologic data and the paucity of water quality data. The resulting TMDLs are invalid. LDEQ does not accept these TMDLs.

Response: The TMDLs were based on existing data plus information that could be obtained with available resources. Each model was developed using the most appropriate hydraulic information and water quality data that were available. A rationale was provided for data use and assumptions and limitations were given. Although LDEQ typically collects more data for model calibration than what was available for calibration of most of these models, EPA considers these model calibrations and the resulting TMDLs to be valid.

2. LDEQ does not consider any of these waters to be impaired due to low dissolved oxygen, nutrients, or ammonia. Many of these waters simply have inappropriate standards and criteria. The resources spent on developing these TMDLs could have been far more effectively and wisely spent on reviewing, approving, and assisting in the development of appropriate standards and criteria for these waters through the UAA process.

Response: TMDLs were developed for these subsegments based on the requirements of Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 and the suspected causes of impairment (organic enrichment/low DO and/or nutrients) for each subsegment in the EPA Modified Court Ordered 303(d) List. TMDLs must be established to meet existing water quality standards. If it is determined that a standards changes is appropriate, the TMDL can be revised to reflect that change.

3. CBODu and NH3-N were estimated from surrogate parameters rather than actual measured data for most of the TMDLs. The TMDL report uses the LDEQ's multi-basin loading database's median ratio values between the ultimate loads and the proposed surrogates. This data was based on the measured data from the last two years of LDEQ water quality surveys. LDEQ objects to the correlation of TOC to CBOD and NH3-N to TKN unless these correlations are taken from water quality data on the modeled waterbody. Our studies have shown only a moderate correlation between these parameters within the same waterbody, however when this correlation was attempted across waterbodies, extreme variability was seen and the correlations were not judged valid. It is possible that a combination of surrogates will obtain a better correlation, such as TOC along with color, turbidity, pH, etc. LDEQ is currently researching these options.

Response: EPA agrees that it would be ideal to have data collected from each modeled waterbody for relating TOC to CBOD and NH3-N to TKN. However, none of these subsegments had sufficient data from which these relationships could be developed. Relationships with surrogate parameters were used only when data for the desired parameter was not available.

4. BOD decay rates were estimated from surrogate parameters rather than actual measured data for most of the TMDLs. The TMDL report uses the LDEQ's multi-basin loading database's median values. This data was based on the measured data from the last two years of LDEQ water quality surveys. It has been LDEQ's experience that these rates vary significantly from waterbody to waterbody and frequently vary significantly within the same waterbody. LDEQ objects to using surrogate data without regard for specific waterbody conditions for these parameters.

Response: Due to the schedule and level of resources available for this project, it was not feasible to perform long term BOD time series analyses on samples from these waterbodies. Given this situation, using LDEQ’s database was considered the best approach for estimating decay rates.

5. A winter projection model was not developed for most of the TMDLs. Winter projection models must be developed to address seasonality requirements of the Clean Water Act. Where point sources have seasonally variable effluent limitations or such seasonal variations are proposed, a winter projection model is required to show that standards are met year-round.

Response: As discussed in Section 4.2 of each report, summer is the most critical season for meeting the year round standard for DO for these subsegments. Therefore, the summer simulation satisfies the seasonality requirements of the Clean Water Act. The available information for point source discharges indicated that the facilities discharging to these waterbodies do not have seasonal permit limits. If any of these facilities wishes to pursue seasonal permit limits, then LDEQ or the permittee can re-run the model to develop seasonal wasteload allocations.

6. LDEQ takes exception to the calculation of a TMDL based on TN/TP ratios derived from waterbodies other than the modeled waterbody. It is LDEQ's experience that the natural allowable TN/TP ratio is waterbody-specific and can vary dramatically between streams.

Response: These nutrient TMDLs were developed using naturally occurring ratios of nitrogen to phosphorus based on Louisiana's narrative water quality standard for nutrients. These ratios were calculated using reference stream data rather than long term monitoring data for each subsegment because the reference stream data were considered to be more appropriate for naturally occurring conditions.

7. LDEQ has not adopted the EPA recommended ammonia criteria (1999) and takes exception to its use in these TMDLs. In general, LDEQ does not accept EPA's use of national guidance for TMDL endpoints. The nationally recommended criteria do not consider regional or site- specific conditions or species and may be inappropriately over protective or under protective. No ammonia nitrogen toxicity has been demonstrated or documented in any of the waterbodies in these TMDLs. The general criteria (in particular, LAC 33:IX.1113.B.5) require state waters be free from the effects of toxic substances.

Response: Ammonia toxicity calculations were performed to ensure that the ammonia loadings that will maintain DO standards will not cause any exceedences of the ammonia toxicity criteria. National guidance for ammonia toxicity was used in the absence of any numerical state water quality standards for ammonia. EPA believes that this evaluation offers assurances that waters will continue to be free from the effects of toxic substances.

8. Algae were not simulated. Was there evidence that algae did not have an impact on the waterbody? Did the contractor have any Chlorophyll a measurements on which to base this determination?

Response: For most of these subsegments, the effects of algae were not simulated in the models because there were no data to clearly demonstrate a need for including algae and the models calibrated well without including algae (i.e., the models were calibrated without having to use unreasonable coefficients to compensate for algal effects).

SPECIFIC COMMENTS FROM LDEQ FOR LAKE ST. JOSEPH:

1. The Fortran program used by the contractor does not adequately show the methodology used in determining the percent reduction based on the projection loading. From the information that is given, LDEQ believes that the chosen method is contrary to the current method in use by the Department.

Response: The percent reductions were calculated by subtracting the projection input value from the calibration input value and then dividing by the calibration input value. This procedure is slightly different than what LDEQ uses but still provides percent reductions that are useful considering the uncertainty in reductions that can be achieved with any specific BMP. These calculations were actually done outside of the Fortran program; the program was just used to calculate the TMDL components (i.e., the numbers in Tables 5.1 and 5.2).